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A comparison between clumped C-O isotope and fluid inclusion temperatures for carbonates associated with Irish-type Zn-Pb orebodies

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Ireland hosts the greatest concentration of discovered zinc per square kilometre on Earth, with past and current production from five Irish-type carbonate-hosted deposits, including the giant Navan deposit. Clumped C-O isotope analysis of carbonate phases offers a powerful new technique to deliver accurate fluid temperatures and fluid O isotope compositions, refining evolving genetic models and developing new tools for exploration. Of particular importance is the ability to obtain accurate temperatures for phases that contain fluid inclusions often too small (<3 μm) for conventional analysis. These include black matrix breccias (BMBs) intimately associated with Zn-Pb mineralization throughout the Irish orefield, and hanging-wall white matrix breccias (WMBs). Fluid inclusions in carbonate phases are also easily modified during regional deformation and metamorphism. Depending on the mass balance between primary minerals and modifying fluids, clumped isotope temperatures may be little changed.

We present the first clumped C-O isotope results for paragenetically constrained carbonate phases from several Irish-type deposits. Preliminary analysis of dolomite from hanging-wall WMBs from Lisheen shows non-systematic temperature variations (100-170˚C, n=5), with calculated fluid $\delta^{18}O$ increasing with temperature. Post-ore pink dolomite at Lisheen and crosscutting calcite veins formed at significantly lower temperatures (67 to 42˚C). Clumped C-O isotope temperatures of 61 to 110˚C (n=4) were obtained for sphalerite-bearing calcite veins from the hanging-wall of the Randalstown Fault near Navan.

A comparison between clumped and standard fluid inclusion temperatures reveals a close match between datasets. Samples characterized by both methods show that clumped C-O temperatures are typically within 30˚C of mean homogenization temperatures (e.g. Clumped/T_h = 88.7 / 80.8˚C, 107.2 / 93.3ºC, 110.3 / 108.6 ºC) using the UEA calibration equation ($\Delta 47 = ([0.0389 \times 10^6]/T^2) + 0.2139$). Extrapolation of this calibration line passes through a sample of Carrara marble experimentally re-crystallised at 600˚C and 1000 MPa before quenching. It is also very close to the theoretical calculations of Guo et al. (2009[1]). Interestingly, the spread of fluid inclusion temperatures within individual samples for carbonate veins from above the Randalstown Fault (e.g. 68-92, 73-102, 85-102, 69-133˚C) is similar to the range of temperatures obtained by clumped C-O isotope analysis for bulk vein samples (i.e. 61.5, 88.7, 107.2, 110.3˚C). Additional samples with well constrained fluid inclusion populations will be analysed for clumped C-O isotopes in coming months.

References

[1] Guo W., Mosenfelder J.L. et al., *Geochimica et Cosmochimica Acta* **73** (2009) 7203-7225.